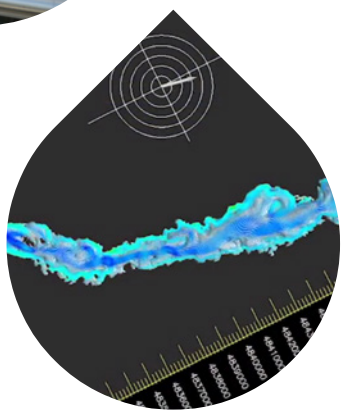


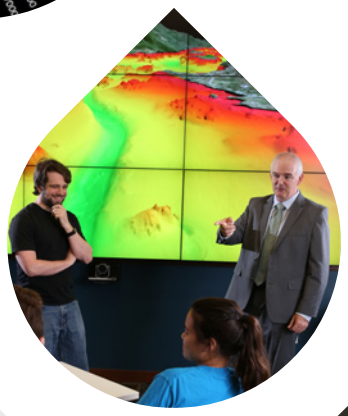
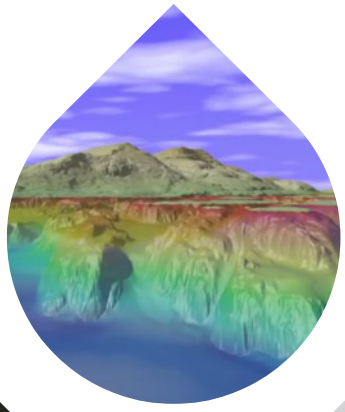

The Jefferson Project
at Lake George

Building the future of freshwater protection

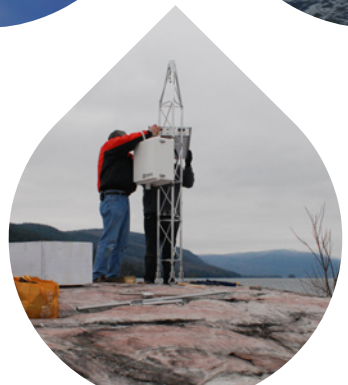
Annual Report | October 2019








UPDATE FROM THE DIRECTORS

A Year of Progress, Promise & New Partnerships

Welcome to the 2018-19 Annual Report of The Jefferson Project at Lake George.

Over the past year — our fifth year of activity — we realized **a critical milestone of the Project, making Lake George the "smartest lake" in the world.** As showcased in this report, now complete is the Smart Sensor Network that monitors physical, chemical, and biological parameters in the lake and surrounding watershed. This achievement is fundamental to the purpose of the Jefferson Project — *to become the global model for sustained ecosystem understanding and protection*.

Having reached this historic plateau of the Jefferson Project, being the smartest lake now empowers application of research and advanced technologies to guide the pursuit of solutions to the problems threatening Lake George, forging a science-to-solutions path that offers a model for water bodies anywhere. This includes lakes of the New York State Harmful Algal Bloom (HAB) Initiative for which Lake George serves as the control lake, having yet to experience a HAB. The Jefferson Project is committed to improved understanding of HABs to prevent their occurrence at Lake George.

The Jefferson Project team has been structured to optimize our work in answering priority research questions critical to informing the sustained protection of Lake George. It now includes more than 100 Rensselaer Polytechnic Institute faculty, staff, and students; nearly two dozen IBM scientists and engineers; and the dedicated staff, consultants, and science and business advisors of The FUND for Lake George. We come from many diverse backgrounds but share one common commitment — to protect The Queen of American Lakes. Please join us and our many partners in this vital pursuit.

High impact questions we are now working to answer include:

- What combinations of factors — increased nutrients and road salts, nutrients in sediments and soils, climate change, and more — are necessary to cause algal blooms and, more importantly, harmful (i.e., toxic) algal blooms?
- How close is Lake George to experiencing a harmful algal bloom?

Sincerely,

Rick Relyea, Project Director, Rensselaer
Harry Kolar, Associate Project Director, IBM Research
Eric Siy, Associate Project Director, The FUND for Lake George

We're establishing the model for ecosystem resilience at Lake George that can be applied around the globe.

Central to building an ecosystem resilience model, we have deployed the world's most sophisticated freshwater monitoring system.

What can the World's Smartest Lake do?

Imagine a highly sophisticated monitoring system for your health. It alerts you to an upcoming sore throat before you even feel it, giving you an opportunity to adjust those weekend plans and follow the system's tailored treatment regimen. It predicts how you will feel with a specific change in diet or sleep in one day, one week, or one year.

This is what we've built for Lake George —the world's most advanced system of integrated sensors, modeling, and data analytics to monitor conditions in real time. From deep waters to streams to soils and weather, over 500 sensors form the Smart Sensor Network. This unparalleled array of intelligent technologies provides quick feedback about changes in water conditions that may signal a new threat or track progress on initiatives to reduce wastewater and stormwater pollution as well as road salt use.

Integral to the power of the technologies now in place is the enormous experimental initiative of the Project that builds on decades of water chemistry surveys and new surveys of the lake's highly intricate food-web. Sensor data is being integrated with data from these surveys and experiments to inform sophisticated computer models for weather, runoff, water circulation, and the food-web.

The Project's Smart Sensor Network now collects more than nine terabytes of data per year that in turn generate 73 terabytes of data by computer models. All of the data fuel the Project's most powerful tool, the Scenario Engine, that creates the capacity to anticipate environmental changes decades into the future, like a new invasive species, increasingly severe and frequent storm events, loss of winter ice cover and much more. This revolutionary innovation establishes the ability to implement effective measures long before water quality declines, ushering in a new generation of preemptive protection that increases the lake's resilience to environmental stressors.

Big data analytics empower breakthrough research on globally significant issues impacting watershed ecology, including harmful algal blooms, invasive species, and the compounding effects of climate change. Creating the world's smartest lake advances the Jefferson Project's founding purpose: *establishing a strategic collaboration that becomes the global model for sustained ecosystem understanding and protection.*

Answering the **toughest challenges threatening Lake George** and fresh waters everywhere

Road Salt Pollution

- Our latest computer model on salt is compiling data from the lake, 12 local streams, and 23 plow truck monitors, showing us how salt enters Lake George, where it goes once it arrives, and how long it persists. We're even modeling salt introduced through groundwater. Taken together, this information provides critical understanding on the effect of road salt reductions being implemented basinwide.
- When snows melt and run off into streams, salt concentrations have measured as much as 10 times the U.S. EPA's threshold for chronic exposure.
- Lab and outdoor tank experiments found that high concentrations of road salt will kill several animal species and promote non-toxic algal blooms. Our research initiated a collaborative set of salt experiments across the U.S., Canada, and western Europe.
- Ongoing salt monitoring will quantify how much salt concentrations decline in the lake and streams, following systematic salt reductions and, over time, what the effects are on lake and watershed ecology.

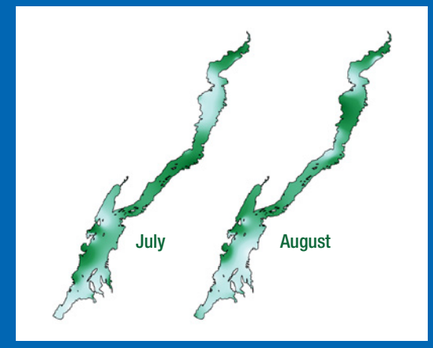
Invasive Species

- We continue to monitor the abundance and distribution of invasive species throughout the lake several times each year in our food-web surveys.
- Our experiments highlight the ecological impacts of invasive species and the conditions that facilitate their spread.
- Our AI and machine learning algorithms are mapping where invasives species are likely to thrive in Lake George, helping us prioritize where to monitor for early detection. This modeling also indicates where they will likely spread and what their expected impacts will be on native species. AI applications also inform and reinforce understanding of why the Aquatic Invasive Species Prevention Program at Lake George is fundamental ecosystem protection.

Excess Nutrients & Harmful Algal Blooms

- Monitoring in deep water has found a 70% increase in orthophosphate and a 32% increase in floating algae since 1980, but absolute concentrations of both factors still remain low compared to lakes around the world.
- Through offshore and nearshore chemistry surveys we are measuring nutrients—phosphorus and nitrogen from fertilizers, stormwater, and improperly treated sewage. To better understand where these nutrients are accumulating, we are collaborating with 50 lake-side residents on a new Algal Tile Survey, identifying locations that experience unusually high amounts of algal growth.
- Through our new in-lake mesocosm facility near Rensselaer's Darrin Fresh Water Institute, we're learning how close Lake George is to a Harmful Algal Bloom (HAB) by conducting experiments to help understand the necessary conditions, including levels of nutrients, to cause a HAB.
- We're collaborating with other lakes that are experiencing HABs to better understand their environmental triggers and we're bringing that knowledge back to Lake George to further improve our work here.

The past summer's harmful algal bloom in the western basin of Lake Erie grew to a size six times larger than the city of Cleveland.
Photo credit: NASA Earth Observatory



Algal hotspots from the 2019 tile survey

ALGAL SURVEYS

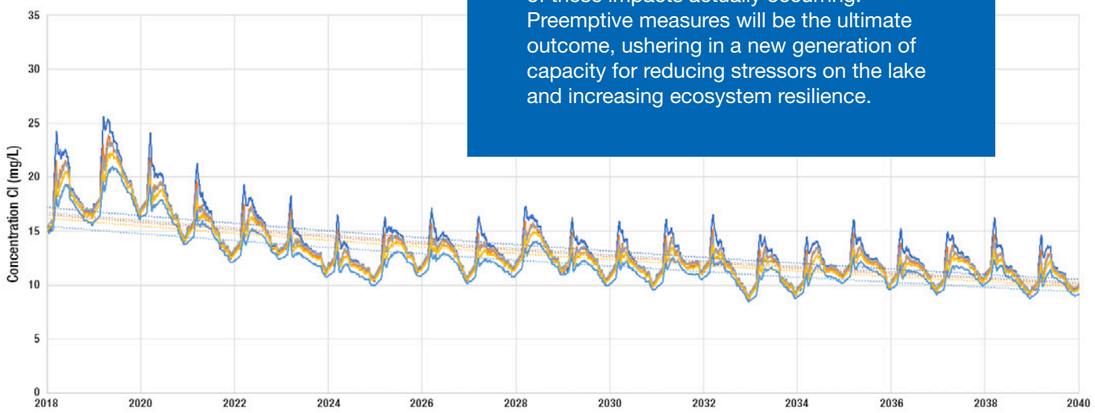
Understanding algae growth, species, distribution, and abundance is critical to determining levels and sources of nutrients and other contaminants, as well as for informing effective measures to limit the extent of human induced influences, such as HABs, to the lake's natural systems.

In 2018, we initiated a survey of the phytoplankton (floating algae) and periphyton (attached algae) at 27 shallow water sites around the lake shoreline. In addition to identifying the algae to appropriate levels of taxonomic resolution (e.g., genus, species), this work also includes investigating modern algal indices of human impacts (excess nutrients, road salts) based on feedback from international experts. The combined effort represents the first comprehensive assessment of spatial and temporal variation in periphyton as it pertains to human activities around the shoreline.

In 2019, we deployed standardized samplers around the shoreline of the lake. Working with residents, we placed tiles on dock posts below water, retrieving them on a monthly basis to directly compare differences in algal growth around the lake as indicators of high-nutrient areas, due to either natural or human causes. This will reveal "hotspots" of algal growth, which then motivate further investigation and mitigation measures, including those being applied by The FUND to identify site suitability for onsite septic systems from which the need for upgrades and replacements are then informed. Such research will help us understand where HABs may be most likely to occur, thereby guiding appropriate actions to curb this potential.

SCENARIO ENGINE

Fundamental to informing sustained protection of Lake George is long-range forecasting of different possible scenarios showing what future lake conditions may be. The complexity of providing such forecasts is unprecedented to the Jefferson Project, yet, the Scenario Engine now being developed will meet this need. Building on the Jefferson Project's current models of weather, runoff, circulation and the food-web, the Scenario Engine will provide forecasting over timescales on the order of decades, out to approximately 100 years. It will produce projections in a matter of minutes for "what if" types of scenarios that account for dozens of physical, chemical, and biological variables. In addition, and of crucial value, the Scenario Engine is designed to overlay leading climate change models. Such ability to model for future conditions impacting Lake George will provide an entirely new dimension of insights on decisions and actions to protect the lake well in advance of these impacts actually occurring. Preemptive measures will be the ultimate outcome, ushering in a new generation of capacity for reducing stressors on the lake and increasing ecosystem resilience.



Modeled by the Scenario Engine, this figure provides an example of projected road salt reduction effects on specific water chemistry measures.

IN-LAKE MESOCOSMS

The first experiment using the 20 in-lake mesocosms installed earlier this year examined the impacts of various road salt concentrations under real lake conditions, from individual species to overall water quality and ecosystem functions. Subsequent experiments are examining the impact of excess added nutrients (nitrogen and phosphorus) on water quality and ecosystem function. These experiments will provide insights into the potential for Harmful Algal Blooms (HABs) in Lake George and other similar lakes. One experimental question currently being evaluated is whether algal blooms (harmful or not) can be stimulated by inputs from water downstream of existing wastewater treatment plants.

TAKING THE JEFFERSON PROJECT ON THE ROAD

Expanding interest in the Jefferson Project led to work with two of the 12 lakes in New York State's Harmful Algal Bloom (HAB) Initiative launched in late 2017. Representatives of several HABs lakes contacted and visited the Jefferson Project at Lake George, including stakeholders from Skaneateles, Chautauqua, and Cayuga Lakes. In the case of Skaneateles Lake, which experienced its first HAB in 2017, serious interest in the Jefferson Project led to a pilot project in 2018. Data collection, analytics, and modeling during that period produced an unprecedented view to the issue and key factors responsible for HABs occurrence there. New capacities for diagnosing causes, predicting, and detecting HABs developed by the Jefferson Project provide the potential for breakthroughs in solving and managing this increasingly severe threat. Similar actions and a longer term commitment are now being developed with leaders at Chautauqua Lake, considered the worst of the 12 HABs Initiative lakes. What the Jefferson Project learns from working with these and other lakes informs the Project's program at Lake George to improve our ability to address the HABs threat. Through enhanced understanding of the complex factors contributing to HABs and the remediation strategies being tested at Lake George, the Jefferson Project is playing an urgently needed role for effective action.

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